

REMARKS

This amendment is in response to the Office Action dated January 5, 2001. Claims 1 - 7 are pending in the application.

Regarding **Claim Rejections** - USC 112(2):

The examiner rejects claims 1 - 5 under 35 USC 112(2) as being indefinite for failing to particularly point out and distinctly claim the subject matter regarded as the invention.

In claim 1, the examiner notes the phrase "material with higher magnetizability and/or higher saturation flux density than a part of said soft magnetic body that is disposed more distant from said air gap [, said part] and belonging to the same said magnetic circuit".

Applicant has amended claim 1 to clarify that said magnetic circuit consists of two regions that have different magnetic properties. The region facing the air gap has higher magnetizability and/or higher saturation flux density and is disposed more closely toward the air gap. Applicant points out that the application is based on the recognition that the utilizable force is dependent on the magnetizability of the soft magnetic material and the flux density in the air gap (see page 1, line 19 - 21). Applicant solves the objective of the invention, namely the increase of the torque-to-bore volume ratio, respectively the force in the air gap while keeping manufacturing costs at a reasonable level, by configuring the soft magnetic body in the machine in such a manner, that in those areas of the machine that are important for the generation of force (i.e. the teeth at the air gap), high-quality magnetic material can be utilized.

High-quality magnetic materials are e.g. cobalt-iron alloys which, compared to other iron alloys, possess an approximately 20% higher saturation flux density (see example on page 3). Grain oriented sheet which, compared to the usual non-grain oriented sheet, produces 70% lower magnetic losses, are also very well magnetizable. But these well magnetizable materials are also considerably more expensive than standard materials. Cobalt costs 100 times more than iron and grain oriented sheet is about 200% more expensive than non-grain oriented sheet.

In the solution in accordance with claim 1, the high-value material is utilized only in those parts of the soft magnetic body that are relevant for the generation of force. Generation of force occurs at the air gap. Therefore, only that part of the soft magnetic body that is adjacent to the air gap is made from the high-value, expensive material.

This approach is new and is not disclosed in any known document.

Regarding **Claim Rejections** - USC 103(a):

The examiner rejects claims 1 - 5 under 35 USC 103(a) as being unpatentable over Hill (-138) in view of Ferreira (5,523,635) and Wiesemann (2,655,613).

Applicant respectfully points out that his US patent 5,818,138 does not have the characteristics as described by the examiner.

1. In Hill (-138) no sheet with variable thickness is shown. The laminations in the machines shown in Figs. 1 - 5 are bundled in axial direction, i.e., the sheet thickness is the dimension of the sheet in **axial** direction. The dimensions

of the sheet vary in the yoke in **radial** direction - this is, however, not the sheet thickness!

2. Hill (-138) does not show "partial areas of the surfaces of said at least two structural groups [(2, 8)] that lie adjacent to the air gap [(6)] having inhomogeneous properties with regard to the magnetic flux," (quoted from claim 1, page 10, line 6 - 8). At the air gap, hard magnets are arranged on magnetically homogeneous soft magnetic bodies. In (-138) Hill describes permanently excited synchronous machines and not reluctance machines as in the present application. The two machine types are fundamentally different.

Except for the characteristic that the machine possesses two structural groups that are moveable against each other, Hill (-138) does not contain any other characteristics that concur with the present application.

Ferreira uses only cobalt alloy for the entire rotor. Here he describes a starter/generator in which the improvement is in particular concerned with the cooling. The aim is high power density which is realized by high speed and an effective cooling. High speed places a high mechanical load on the rotor and requires a stable construction which suggests a unitary design.

In only one passage of the text is it mentioned that the entire rotor sheet packet (116) may be made of vanadium-iron-cobalt sheet (2V49Feo) in order to maximize power density. This reference is not further elaborated and neither is it contained in the abstract nor in the summary of the invention. The low weight accorded this reference does not suggest to the professional to contemplate in depth the use of this expensive material.

This document merely indicates that professionals will also consider cobalt alloys for the improvement of power density. It has been known since a long time that cobalt-iron alloys provide the highest saturation flux densities. The range of application is, however, severely limited due to the high material cost - cobalt costs 100 times more than iron.

Ferreira manufactures only the rotor from the expensive material, and segmentation of the rotor sheet packet or assembly from several segments is not provided. The requirements of highest reliability and highest speed prevent the professional from measures that might cause a reduction of rotor stability.

The approach to a solution by the applicant, on the other hand, reduces material costs considerably by utilizing the expensive material only in those areas of the magnetic circuit in which parts of the soft magnetic body, for design reasons, possess a reduced cross section. This is the case for the teeth. An improvement of the capacity in the same design space is achieved at reasonable costs.

This approach to a solution can not be perceived in Ferreira. There, the entire rotor is manufactured from the expensive cobalt alloy, but not the stator. Thus, the capacity of the machine in relation to the air gap surface is limited by the saturation in the stator sheet packet. The considerable additional costs for the rotor are justifiable only by the reduction of rotor losses. In the rotating part of the machine, the realization of efficient liquid cooling is considerably more difficult. Further, the inner diameter of the rotor provides a significantly smaller cooling surface for heat dissipation than the outer diameter of the stator. Only in view of avoidance of cooling problems (in spite of high

frequencies and magnetic flux densities) can it be understood that the entire rotor sheet packet is manufactured from an expensive cobalt-iron alloy.

To summarize: Ferreira does not give an indication of the design disclosed in claim 1 of the present application.

In the PCT-process, a single document which describes the use of two different soft magnetic materials in one soft magnetic body - **US 4 698 537** (Byrne, John et al.) - was found. Byrne shows stator poles with pole shoes, and each pole has a layer with a lower iron content, thus saturation of the soft magnetic body does not occur at the air gap but in this **depletion layer**.

The magnetic field intensity generated by the current of the stator coils can, due to the lower iron content of the "depletion layer", bring about only a reduction of the flux. This technical teaching is in sharp contrast to the approach of the present application to increase the amount of the air gap flux at the same air gap surface (design size).

Byrne pursues the **objective** of improving the start-up performance of a two-phase reluctance motor and to this end accepts that part of the field intensity decreases in the depletion layer of the rotor poles instead of generating torque in the air gap. This loss of magnetic field intensity in the depletion layer decreases the capacity of the motor.

The applicant pursues the **objective** of improving the capacity of the reluctance machine. He achieves this by utilizing high-quality magnetic materials in those areas of the magnetic circuit in which the flux flows through a reduced iron cross section. **Contrary** to Byrne, the applicant aims at avoiding the decrease of field intensity in the iron up to

highest possible flux densities, and thus, to good effect, concentrate energy conversion in the air gap.

Byrne does not pursue this approach at all. The professional does **not** perceive from Byrne how to increase the effectiveness or the power density of reluctance motors. Instead, he receives a suggestion for the improvement of the start-up performance, which causes exactly the opposite, namely a decrease of effectiveness and power density.

The differences to Byrne are more clearly elaborated by the amendment to claim 1. Claim 1 is sharply delimited against Byrne. No other document contains the utilization of different soft magnetic materials in a stator or rotor. A combination of other documents with Byrne does not lead to a solution of claim 1 either, because Byrne is pursuing an opposite objective.

To summarize: Patentability of amended claim 1 was confirmed in the PCT-process (see preliminary international examination report).

Claim 6 describes an independent variant of the approach to a solution in accordance with the invention.

Grain oriented material is more expensive by a factor of 2 to 3 than standard lamination material. For optimal magnetic properties, the flux must flow predominantly in the direction of the grain orientation which is produced by rolling. In soft magnetic bodies arranged radially within a cylindrical air gap, the teeth which are made of grain oriented material can be extended radially toward the center till they meet. In this case, the high-value, soft magnetic material is also optimally utilized at the air gap, however, without another part of the soft magnetic body being made of a less expensive material. In this case, it is advantageous to

use only grain oriented material and to dispense with the utilization of two different materials, because additional process steps and expensive tools will not be required.

Independent claim 6 describes this variant of the solution which is not known from any document either. Neither does a combination of documents provide the professional with the solution described in claim 6.

Mueller (5,909,072) shows a brushless, three-phase DC motor with a rotor that has permanent magnets glued to it and a stator that is made of cut sheet. This cut sheet shows spooled poles and, between them, small non-spooled intermediate poles, however, the pole surface of these intermediate poles amounts to only one third of the pole surface of the spooled poles. They are, therefore, not half poles that correspond to 50% of the main poles. Mueller does not teach half poles, but third poles which occupy the space that results from the phase offset.

Neither does Mueller show a "structural group with at least two electro-magnetic units" (= characteristic 1 of claim 6 and 7). Although the stator of Mueller is a structural group, these structural groups are not differentiated. The professional does not perceive from Mueller to separate the stator into units which "consist of at least one spooled pole segment and two non-spooled half pole segments" (= characteristic 2 of claim 6).

Furthermore, the poles of Mueller are parts of a cut sheet and not segments. Segments are individual structural components that can be premanufactured separately and subsequently assembled. Only separately premanufactured parts can as "half pole segments [(5)] abut at least one pole segment in the yoke area" (characteristic 3 of claim 6).

Only these three characteristics, none of whom are taught by Mueller, make it possible to utilize the advantageous properties of grain oriented material. The use of this material distinguishes claim 6 additionally from the design by Mueller.

To summarize: Mueller is different in several essential characteristics from the present invention and no other document teaches the professional the surmounting of all these differences.

Wiesemann (2,655,613) shows a rotor for dynamo-electric machines with a spider-like core. Each arm has a pole shoe fixed to its radial outer end. The pole shoes distribute the magnetic flux about the rotor. The pole shoes provide a larger cross-sectional surface for the flux than the arms. It is, therefore, not appropriate to produce the pole shoes from a high-value material. This type of machine does not work in accordance with the reluctance principle and is fundamentally different from the machine type of the present application.

Wiesemann does not show a "structural group with at least two electro-magnetic units" (= characteristic 1 of claim 6). Neither does he show half poles and segments that abut in the yoke area.

To summarize: Wiesemann is clearly differentiated from the present invention as described in claims 1, 6, and 7 and neither does he show these characteristics in combination with other documents.

Patentability of amended claim 6 was confirmed in the PCT-process (see preliminary international examination report).

Applicant amends claim 7 and formulates this claim as a third independent solution. By fixing the units which consist of a spooled pole between two non-spooled half poles by means of a T-shaped holding element, assembly is simplified and manufacturing costs are lowered. The T-shaped holding elements separate the soft magnetic body, thus avoiding stray fluxes and increasing the torque-to-bore volume ratio. Furthermore, the units can be prefabricated automatically, achieving lower coil resistance and reduction of ohmic losses. With claim 7, the objectives of the present invention are thus achieved independently of the other claims.

To summarize: There is no document that teaches the fixing of units that consist of one spooled pole between two non-spooled poles by means of T-shaped holding elements.

Neither document Hill (-138), Ferreira, Mueller, and Wieseemann show the characteristics of claims 1, 6 or 7 of the present invention.

The prior art will be considered in the disclosure, after the claims are allowed.

Reconsideration and allowance of the application is respectfully requested.

Respectfully submitted



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